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ABSTRACT

This digest examines the best evidence available on mathematics achievement in rural schools and offers recommendations for further research. Findings on the mathematics achievement of secondary students are presented, based on analyses of the National Assessment of Educational Progress (NAEP) in 1996 and 2000, the Longitudinal Study of American Youth in 1987-89, the National Educational Longitudinal Survey of 1988, and the NAEP for 1992 and 1996. Nationally, no mathematics achievement gap was found between rural students and students in nonrural, suburban, or urban classifications. A rural-nonrural achievement gap was found in 40 percent of states--half the time it favored rural students. Conditions of schooling accounted for a large proportion of the variance associated with state-level achievement gaps. These findings refute charges of rural inferiority in relation to national averages. School and system characteristics are listed that might influence mathematics learning and that should be researched in the rural context. (SV)

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Mathematics Achievement in Rural Schools

Craig B. Howley

Rural communities need an infrastructure of good mathematics knowledge, according to some observers. Moses and Cobb (2001), in particular, argue that mathematical knowledge will, in the new century, figure as a path to political and cultural power, much as the capacity to read and write served in the 19th and 20th centuries.

What is the baseline of mathematical knowledge among students in the rural United States? Poverty in nonmetropolitan areas exceeds that in metropolitan areas (Jolliffe, 2002), and, for this reason, one might reasonably suspect that mathematics achievement in rural schools is depressed as compared to the national average. Is this really the case? This Digest assesses the best evidence available and concludes with recommendations for further action, based in part on conclusions reached by a national effort to develop new research about mathematics education in rural places.

NAEP Reports of Rural Mathematics Achievement

In both 1996 and 2000, the National Assessment of Educational Progress (NAEP) mathematics scores of students in rural and small-town schools exhibited some statistically nonsignificant negative differences from the national average at all grade levels tested. Although nonsignificant differences are sometimes interpreted as harboring practical significance, absent a consistent pattern in the directionality of such differences (i.e., positive or negative), such inferences are unwarranted.

Two inferences about NAEP trends do seem warranted, however. First, across 25 years of testing and regardless of locale definition, there has been little change—increase or decrease—in the mathematics performance of rural students. Second, with rare exceptions, the recent performance of rural students at all NAEP grade levels barely differed from the national average (see Howley, 2002, Table 3). The observed, nonsignificant differences are small, they sometimes favor rural and small-town schools, and they harbor no practical implications.

Current Research on Math Achievement in Rural Areas

NAEP reports consist largely of descriptive data; seldom do they test hypotheses or develop fine-grained explanations of the accurate descriptions they provide. Only empirical studies with an explicit base in theory can offer such explanations. The extant research literature is thin, but three recent quantitative studies provide a surprisingly comprehensive picture of mathematics achievement among rural students: Haller, Monk, and Tien (1993); Fan and Chen (1999); and Lee and McIntire (2000).

Haller and colleagues (1993) examined the 1987-1989 mathematics scores of 10th-grade students on tests administered by the Longitudinal Study of American Youth (LSAY). The Haller team sought to explain the lack of statistically significant findings in previous inferential studies (not summarized in this Digest) as a possible case of inappropriate testing: the result of using norm-referenced tests with reputedly inauthentic items not deemed to represent higher-order thinking. Rural schools, after all, offered fewer advanced courses than other schools, and such a shortcoming might yield deficient higher-order thinking among graduates of rural schools. The researchers characterized the LSAY math test as more reflective of higher-order thinking.

Haller and colleagues (1993, p. 71) concluded, "While large schools offer more advanced courses than do small ones, those offerings appear to have no influence on average levels of student achievement." In other words, according to these researchers, a more narrow rural curriculum in mathematics did *not* depress higher-order mathematics thinking (as measured on the LSAY tests). The researchers *did* find a positive relationship (r = +.38) between proportion of students enrolled in more advanced courses and achievement levels.[1]

A problem with the Haller study is that national averages obscure a great deal of variation—specifically regional and state achievement variation—in mathematics test scores. State and regional variation require critical analysis for several reasons. First, the ultimate authority for schooling rests with states, and management of their school systems can differ sharply. Second, regions of the nation exhibit sharp differences in economies, cultures, ethnicities, and the structure of schooling. Third, despite an average exhibiting parity of mathematics achievement, rural areas exhibit overall differences from the national norm that are still important to policy and administration (e.g., differences in school and district size). Without attention to these sources of variation, educational research cannot inform improvement efforts. Fortunately, within this small literature, Fan and Chen (1999) examined the issue of *regional* variation in mathematics achievement, whereas Lee and McIntire (2000) addressed *state* variation in their study.

Fan and Chen (1999) examined test scores from the National Educational Longitudinal Survey (NELS:88) data set. Separate analyses were conducted for 8th-, 10th-, and 12th-grade students. These researchers were concerned primarily to provide a *systematic* test of the hypothesis of rural deficiency. That is, they were particularly concerned to overcome five methodological shortcomings of previous studies (i.e., sampling issues; inconsistent definitions of locale; and the influences of socioeconomic status, ethnicity, and school sector [private vs. public] as potentially confounding variables). Their analyses were carefully executed and comparatively sophisticated. The results are very simply stated: with careful controls in place, no practically significant differences between mathematics test scores existed by locale (rural, suburban, and urban).[2]

Lee and McIntire (2000) used NAEP 8th-grade data for 1992 and 1996 to investigate state-level variability in rural versus nonrural mathematics achievement, as well as to investigate the potential influences of six "schooling conditions" on that variability. This study, among the three cited, is notable for its exclusive consideration of *mathematics* achievement. (The others had included other subjects as well as mathematics.) This more narrow focus allowed the researchers to make hypotheses about, and to investigate the variation in, the conditions of mathematics instruction that might influence rural mathematics achievement at the state level as well as the national level.

The results were somewhat surprising. For the 1996 comparison, the rural mean was 276 and the nonrural mean

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was 268. With standard errors of 1.92 and 1.80, the implied standard error of the difference (5.26) indicates a statistically significant difference in 1996, *favoring rural students*. The difference, in fact, equates to a respectable effect size of +.23. This *positive* difference is equal in magnitude to the largest pre-1986 *negative* difference between disadvantaged "extreme rural" and the national average (see Howley, 2002, Table 3). The 1992 differences were not statistically different (265 rural, 267 nonrural).

A great deal of variation, however, was evident at the state level. In fact, in 7 (of 35) states, and contrary to the national average, *nonrural* student aggregate scores were *higher* than those of rural students (Georgia, Kentucky, Maryland, North Carolina, South Carolina, Virginia, and West Virginia).

To account for such variation, Lee and McIntire assessed the influence of six policy-related "schooling conditions" prospectively evident at the state level. Across the 35 state cases, these six conditions, in regression analysis, account for an impressive 84% of the variation in state-level, NAEP 8th-grade mathematics achievement among the rural portions of the respective states' populations and 69% for the nonrural portions (still high). Focusing on three of the conditions, the researchers reported

> *Rural students* in states where they have access to instructional support, safe/orderly climate, and collective support [collegiality] tend to perform better than their counterparts in states where they don't. (emphasis added; Lee & McIntire, 2000, p. 171)

The analysis, although comparatively fine-grained, is not sufficient to generalize the conclusion to future years. Instead, it provides substantial material to inform hypotheses in subsequent research. In particular, Lee and McIntire's work strongly suggests that the most interesting and useful work to be done lies below the national level, and can profitably address issues of state and local context.

Conclusions and Recommendations

Although the studies reported here use different definitions of rural, it seems likely that mathematics achievement in rural and small-town schools has converged with national averages—whether or not scores are statistically controlled for the effects of poverty and other influences. Key conclusions from this assessment follow:

- Currently, a national rural versus nonrural mathematics achievement gap does not exist.
- Currently, neither a national rural versus suburban, nor a national rural versus urban mathematics achievement gap exists.
- Currently, at the state level, a rural-nonrural achievement gap exists in 40% of the states—half favoring rural students.
- Conditions of schooling account (variably and somewhat hypothetically) for a large proportion of the variance associated with the rural-nonrural achievement gap at the state level.

What do these findings *mean?* Do we need to pay any attention at all to mathematics teaching and learning in rural places?

Skip Kifer (2001) quite rightly advises that comparisons of *variation* rather than of *averages* constitute the most important work for researchers. The advice is apt, but to challenge the charge of inferiority (which persists in the case of rural culture, lifeways, and talents), the study of averages has practical and theoretical merit. This Digest provides evidence that charges of rural inferiority in comparison to national averages are weak.

Regardless of locale, meaningful variability exists at the district, school, and classroom levels—as well as at the state level. Some of this variability might be random, so that it harbors few practical implications. But much of it is probably not random. Much of it may be related to features of locale over which humans might exert some influence for the common good of more and better mathematics learning (Howley, 2003), including

- structural features of the educational system (e.g., class size, school size, district size, and the relationships among them)
- equity of local resources (e.g., income distribution in the community, parity of instructional resources among district schools, patterns of assignment of the best teachers among a district's schools)
- the local culture of schooling (e.g., 'embeddedness' of the school in the community and the community in the school, conceptions of educational purposes and effects)
- intentions of teachers and administrators (e.g., school climate, professional collegiality, relationships among students and between students and educators)
- adequacy of resources (e.g., school funding levels in view of challenges, tax effort, staff turnover)
- degree of collective purpose (e.g., student-centered focus, extent of tracking, equity of educational outcomes)

A good deal of educational scholarship, of course, has considered such issues, but very little attention has been directed at the influences present in rural places that support mathematical learning or invoke resistance to instruction in mathematics. Quantitative studies can and should be informed by such meanings. But rather than seeking simple differences, future quantitative studies should consider variation, interactions, dilemmas, and contradictions, for these are the challenges that make practice and improvement difficult.

Notes

1. There are numerous explanations for such a result. Indeed, the highest correlations by far with 12th-grade math achievement in this study are those with prior achievement—a powerful control variable in this study, and the only one to prove statistically significant in the regression analyses (see authors' discussion on p. 70).
2. With very large sample sizes, some statistically significant differences will always be found; effect sizes, however, interpret the degree of influence exerted by such differences. The few such differences found in this study are associated with very marginal effect sizes (e.g., a magnitude of about .01).

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